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THE MISSION AND LIMITATIONS OF SCIENCE.

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An address delivered at Topeka, January 1, 1903, before the thirty-fifth annual meeting of the Kansas Academy of Science.

IT is not my purpose to attempt to trace the development and influence of science from its origin to the present time. This would, at best, be largely speculative. I wish, however, at the outset to define the domain of science, so that our thoughts may be directed in the same channels. We all have some idea, it may be more or less vague, as to what is meant by the term "science," but its definition, I fancy, is not easy to any one. I question if any of the body of workers commonly called scientists would call mathematics a branch of science, as the term is now generally used, although in no branch of learning is there possible such absolute logic and systematic arrangement of the material under discussion, and the dictionary defines mathematics as the science that treats of quantity. Mathematics, however, deals with the abstract. It is the product of intellect working upon itself. While it is applied and is of the most transcendent importance to the concrete operations of every-day life and the sciences, it does not essentially deal with the concrete, unless it be true that the axioms of mathematics, which constitute the unprovable bases of assumption upon which its magnificent superstructure is reared by successive steps of pure logic, are themselves but statements of concrete experiences of man in his contact with nature, which have by their unvarying associations become so impressed upon the organization, that all agree that to deny them is an absurdity. Be that as it may, mathematics is essentially a matter of pure intellect, and does not come in the field of learning that is included within the term "science" as it is most frequently heard.

Science deals with facts—that is, occurrences that are matters of observation. It is concerned essentially with the concrete, and with pure reasoning directly applied to the concrete. History considered merely as a record of events or facts is not science. Neither is literature, though it may be rich in facts. As I conceive it, science is the study of occurrences or phenomena of nature in their relation to each other. The study of the relations among facts constitutes the essence of science. When we speak of "the sciences" we must understand that this is merely for convenience. The sciences are but sections, more or less distinct, of science, and in truth the more we learn of the sciences the less distinct they become, and the more and more they merge into the all-inclusive unit, science, which is knowl-

edge systematically arranged, so as to display what we are pleased to call the laws of nature, though more fittingly designated as the order of nature. Science is a continuous study of antecedents and consequences, causes and effects, interrogation and reply, action and reaction, the source and outcome of every change. It is the intellect applied to matter and energy.

All through the ages man has been slowly acquiring the knowledge that makes the warp and weft of science. Much of this has been beaten into him by Dame Nature with her kindly but unchanging order. "The soul that sinneth it shall die," "Hear and your soul shall live," are truths that the eons have been teaching man. The seeming harshness of the first is but one side of the shield; and while the punishment that nature gives ignorance and foolishness is inexorable, it is really but another manifestation of the constant faithfulness which follows seed-time by harvest, and in so many ways gives forethought a richer reward. When man first recognized an item in the order of nature, science was born; when he first utilized that knowledge to ameliorate his condition, civilization was born. The growth of both was extremely slow. Truth may be likened to a great sphere of crystal which must be picked to pieces. As long as it presents its smooth surface but little hold can be gained and progress made. One must with great labor and slowly go down deeply at some point, or excavate a trench from the sides of which rapid progress may be made. So with science, the more we learn the more we can learn; but the beginnings of knowledge came with such painful slowness that there can be no doubt that thousands of years were required to make known what seem to us fortunate "heirs of all the ages" as very simple things. The acceleration in the rate of acquisition of knowledge of nature's order was slow, and it is safe to say that more was learned during the last century than during all time before.

Modern civilization is the product of science. It is the direct result of the partial discovery of the laws of nature that we have thus far attained. The future of civilization is inseparably bound up with the progress of science. As yet only the simpler relations of matter and force are at all thoroughly understood, and in the more complex relations, involving life and the relations between living things, we have scarcely made a beginning. I shall not take your time to enumerate the stock illustrations of the progress of the nineteenth century; the newspapers do that for us, and it may be safely assumed that they are familiar to all, though I believe that they are taken so much as a matter of course that the younger ones of us do not realize how tremendous the change has been. I wish, however, to call your attention to one or two phases of this growth of civilization.

First, this entire progress in the mastery of nature and in directing her forces is a triumph of reason, of intellect. Intellect to many seems cold, devoid of feeling, knowing neither pleasure nor pain. To some, reason seems antagonistic to love and reverence. We all live and work for happiness, present and future. Whether we have analyzed our motives or not, whether we understand ourselves or not, that is our object. The channels through which it reaches us are many and diverse—some are more open with one, others with another; but I wish to insist that, so far as those due to civilization are concerned, intellect must be given the credit. I do not for a moment underrate the place that physical pleasures fill in making life worth living. The desire to gratify them often serves as a stimulus to intellectual effort, and thus they may at times even accelerate material progress, but they are not as a rule directly productive of it. The delights of the senses, while so alluring as to become the sole aim of many, are in themselves non-productive. Reason must be the great producer, and more than that, she must ever stand as the inflexible guardian of her products. Without her stern protection, the temptation to present pleasure would dissipate past accumulations and destroy future possibilities. By means of the intellect the pleasures of the average individual to-day exceed those of ancient kings. Means of transportation and communication alone have multiplied them many fold. The sublime beauties of mountain, plain and sea may be enjoyed by hundreds instead of one. Through modern machinery, the perfection and wonderful accomplishments of which are almost incredible, the ordinary home possesses equipment, beauty and comfort exceeding that of Solomon's palace. I will not enter into further detail, but if you will think the matter out you will see that most of our pleasures, and especially the great abundance of them, are due to the dominance of reason—that is, the dominance of science.

Appreciation of the value of science in every-day life is shown in the establishment of technical schools and their growing favor with the people. It is also shown by the establishment, under federal patronage, of an agricultural experiment station in each state, in which the resources of science are brought to a direct bearing upon the problems of plant and animal production, with their many ramifications into the realms of chemistry, physics, physiology, biology, geology, and engineering. The growth of nature study in the schools is another indication of the appreciation of science, though doubtless this movement may at times degenerate to the level of a fad. Agitation has begun, and will continue to some tangible result, looking to the teaching of the simple scientific principles of agriculture in the common schools of the country. The art of cooking, now taught in so many schools

and destined to be introduced far more extensively, is not imparted merely as a series of rules, but with the reasons for procedure explained upon chemical, physical and physiological principles. Schools of mechanical, electrical and mining engineering are monuments to the confidence of the people in training in science.

Science has revolutionized education. I have not the time now, nor indeed the detailed information necessary, to prove this, but it is more or less a matter of common knowledge that not so long ago a classical education was the only one available, and law, medicine and theology the sole occupations of men of education. The intellectual training that the classical education gave and the culture that it imparted are undoubtedly of great value, but with the swift pace of modern times, and the important part that science plays in so many walks of life, the demand has arisen and been met for an education to the useful. In this, time has frequently been shortened, and culture as such curtailed, perhaps to too great an extent, but the chief aim, that of teaching one to do something, has been met. I think, too, that a scientific education to the useful may be, and is in most cases, as rigid in discipline as a classical course, and perhaps even more efficient as a means of training to think. Mathematics is always included, and proper teaching of the sciences must of necessity train the reasoning faculty, as well as heighten the powers of observation. The graduate of a technical school is usually able to adapt himself at once to the stern realities of active life, while the classical graduate, outside the learned professions, may be as ignorant as a child upon much that makes up modern life and activities. The demand for scientific education is such that now no institution of any rank altogether neglects it, and many of the universities have schools of technology. Undoubtedly a great mission of science is to serve mankind, by making the material comforts of life more abundant.

I should, however, be doing science a grave injustice were I to leave you with the impression that she is merely the handmaid of the physical pleasures. The study of science for its own sake yields a pleasure of a loftier type. The joy of discovery, the satisfaction that accompanies mere knowledge, is one of the rewards of education. How often do we hear the carping comment, "What is it good for?" or, "What's the use of studying that?" or, "That's all theory; I want something practical." Now, these sentiments represent one aspect of the case, and an important one, but I wish to insist that it is not, and ought not to be, the only attitude. I have no sympathy for the man who has no use for knowledge that cannot be turned into dollars the next day. The satisfaction in life that accompanies an understanding of the processes going on about us should be very great. Probably

there are differences in tastes; occasionally we see some one who seems to have no interest in knowledge of causes; but nearly all children and young people, those who have not been made sordid by the buffetings of hardship, find a real and pure pleasure in knowledge.

I believe that the pursuit of science from the love of truth, with no thought of material reward in cash or honors, is the source of most of the advantages of science that we enjoy. We hear much now of the wonders of electricity, and the place that it has made in our daily life is truly marvelous. I presume that if a hundred educated people, take them as they come, were to be asked who deserves the most credit for this, the majority of them would have to admit that they did not know, and most of the remainder would name Thomas A. Edison. The importance of the work of Edison is not to be questioned, and his name will be written large on the roll of those who have benefited their race by the practical application of science; but back of his work, and far above it in merit, lie the fundamental discoveries of Joseph Henry, a professor of mathematics working at natural philosophy from love of it, and of Michael Faraday, a bookbinder fascinated by science, whose discovery that a magnet moved across a closed conductor generates an electric current therein is the foundation of the modern dynamo. Faraday was a typical man of science, who found his greatest pleasure in studying the workings of nature merely to know them. All honor to him and such as he. While those who have developed and applied fundamental discoveries are not to be despised, as some affect to believe, the greater honor belongs to those devotees of pure science who make the applications possible. I think I am not going too far in saying that the man who is always asking "What good will it do?" or "How much is there in it?" will never accomplish great things even in applying the discoveries of others.

In view of the great accomplishments of science and the stupendous bulk of facts amassed, the question may well be asked: "Is this process of discovery to continue at the same or an accelerated rate in the future, or are the chief generalizations of science now in our possession?" I see no reason why this question might not have been asked at almost any time in the past. It is the tendency of each human society to ascribe to itself accession to the acme of eminence. It is true that facts are not as near the surface now as they were before Faraday, but it is also true that the available weapons of science are correspondingly more potent, and I suspect that a man of genius—a Faraday, a Huxley, or a Darwin—can make discoveries to-day as easily as in 1830. He must acquaint himself with the essential accomplishments of the past, to be sure; and the longer time endures, with its annual additions to these accomplishments, the more preparation

the discoverer of the future will require, but at the same time the greater will be the facilities for imparting that knowledge. The fad for compelling every student of physics or chemistry to discover all of his facts for himself will not endure. He will be permitted to store his mind and memory with the accomplishments of the past, repeating and verifying these to the extent necessary to fix the most fundamental, and to discipline his powers of observation and deduction, and to train him in manipulation. He will then make discoveries of his own, if he has the natural endowment, without which no education and no opportunity is of any avail.

One of the most distinguished physicists of the present day expressed the view that the physics of the future would consist in working on known phenomena and determining constants to the fourth decimal place, or words to that effect. Since then the Roentgen rays have been discovered by a worker in pure science, whose experiments would certainly have been ruled out by the utilitarians, but who has received unstinted praise, because of the practical applications that have been made of his discovery. Since then a more remarkable discovery has been made, of which few, comparatively, know as yet. I refer to the radio-activity of matter. I hold in my hand a mineral of very ordinary appearance, which none of you would look at twice unless your attention was especially drawn to it. Yet this humble substance, without any known source of stimulation, is constantly emitting radiations that will penetrate opaque substances and affect a photographic plate, and possess other properties that make them an unsolved riddle to the physicist. Within fifteen years a revolution has taken place in our views concerning the condition of substances in solution. A new view, supported by its power to co-ordinate diverse known phenomena and to suggest lines of research that in turn add new force to itself, has carried everything before it. It may not, probably will not, remain as it is, but it is a step in the upward progress. Within ten years, so every-day a thing as air has, by the searching methods of modern chemistry and physics, yielded no less than five new elements, that apparently exhibit the hitherto unknown property of possessing no power to enter into chemical combination. No, it will be several years before there are no discoveries remaining to be made in physical science.

I believe, however, that the greatest progress of the future will not be in the fundamental general sciences, chemistry and physics, but in the special sciences all of which rest on them. The study of the phenomena that involve life, both vegetable and animal, is to lead to tangible results. The progress that is being made now in physiological chemistry, especially as related to disease and immunity, is sur-

prising to one who has not been in position to note its progress from week to week, and there can be no doubt that we are on the verge of great advances in that field. We may easily believe that medicine will become a science, instead of a series of experiments with drugs of which we know little upon organisms of which we know less. There are those who even dare to hope that death itself will be conquered by the fuller knowledge of cell processes that the future will reveal. Agriculture, with its twin lines of effort, plant production and animal production, involving, as they do, a more complicated play of natural forces than is displayed in any other industry, will become less uncertain as controllable factors become better understood. Domestic economy may become a science.

I believe that the greatest field for the progress of the future is that which includes consciousness and mentality as factors in the phenomena. I yield to none in admiration for the courage and the genius of the scientists of the past, but it seems to me that there has been by most scientists a tendency to ignore certain classes of phenomena, or to regard them as fraudulent and not even worthy of exposure. While scientists have assailed the conservatism of the theology of the past, they are not themselves free from the conservative spirit that permeates humanity, and, indeed, is in many ways the safeguard of humanity. The tendency of the study of science is toward materialism, and is it not true that this tendency has attained too great force in the past, and led many of us to neglect or discredit phenomena that appeared to be outside the realm of chemistry and physics? If I mistake not, it is within the memory of most of us that the attitude of science towards mesmerism, as it was then called, was one of incredulity and of pity for the deluded victims, mingled with a pharisaical self-satisfaction in the fact that we were not like them. But we have lived to see what was discredited as mesmerism become respectable as hypnotism, and a real remedial agent, the power of which may extend even to the production of complete anesthesia. We have lived to see a powerful organization built up, which has been characterized as neither Christian nor scientific, while claiming to be both, the binding force of which lies in the subtle but intimate connection between body and mind. Some of us will live to see great advances in the study of the mind as related to the body. Even crude observation shows that there is some connection between mental states and physiological processes, and a bold and open acceptance of this as a field for legitimate investigation will probably yield rich returns. I may add that I do not believe that these returns will be obtained either by those who deny the existence of matter or those who believe in nothing else.

The phenomena of spiritualism, so-called, present a field that should yield valuable results of some kind and ought to be a legitimate subject for investigation. Yet Alfred Russell Wallace, who was everywhere recognized as a great scientist, almost lost his reputation by his study of the subject and subsequent adhesion to the faith of spiritualists. Sir William Crookes, great both as a physicist and chemist, investigated the phenomena, and has suffered more or less for it ever since. Is that right? Is it scientific? Do not make the mistake of supposing that I am advocating the claims of Christian science or spiritualism. Far from it. I believe, however, that where a wide-spread belief prevails, there is something to be learned by scientific study; there is a grain of truth, at least, if we will only thrash it out, and my contention is that it is the duty of scientists to hold toward these obscure phenomena the attitude of science instead of prejudice, and, while demanding as incontestable evidence here as elsewhere, to encourage rather than taboo investigation in these lines. The old question, "If a man die shall he live again?" is one which, bidden or unbidden, rises in every breast. Its answer we know no better than did Omar Khayyam, who wrote:

"Myself, when young, did eagerly frequent
 Doctor and saint, and heard great argument
 About it and about: but evermore
 Came out by the same door where in I went.

"Into this universe, and *why* not knowing
 Nor *whence*, like water willy-nilly flowing;
 And out of it as wind along the waste,
 I know not whither, willy-nilly blowing.

"Up from Earth's center through the seventh gate
 I rose and on the throne of Saturn sate,
 And many a knot unraveled on the road;
 But not the master-knot of human fate.

"There was the door to which I found no key;
 There was the veil through which I might not see:
 Some little talk awhile of ME and THEE
 There was—and then no more of THEE and ME.

"Earth could not answer; nor the Seas that mourn
 In flowing purple of their Lord forlorn;
 Nor rolling Heaven with all his signs, revealed
 And hidden by the sleeve of night and morn."

"To hope is one thing, to believe another; to know is quite another." It is the future task of science to contribute something to the unraveling of the "master-knot of human fate."

The experimental study of the mind and consciousness will occupy the scientists of the future far more than it has those of the past.

The mystery of consciousness, so profound as to seem impenetrable, will certainly yield something to experimental investigation. The subject possesses an interest amounting to fascination, but it is entirely beyond my ability to discuss. The distinguished Professor Minot, in his presidential address before the American Association for the Advancement of Science, last summer, advanced the hypothesis that the universe consists of matter, energy, and consciousness. Is it too much to say that consciousness presents the most profound problem of science? Is it too much to believe that the future holds some Newton who will reveal the solution?

Human nature in its natural condition is positive, prejudiced and narrow. The study of science gives breadth; the attitude of science is one of receptivity. He who has in part gained the clearer vision, who has penetrated some of the mists of verbiage, realizes that all knowledge is relative; that absolute knowledge of even one thing is not within the power of the human intellect; that not only the infinitely little and the infinitely large are beyond our deepest ken, but the every-day phenomena which so many think they know. In ultimate analysis, I think we can be sure of but one thing, "I think, therefore I am." This, only, is positive; all else is relative. When we reach that point we are humbled; we realize our insignificance in the universe, and we drop our attitude of positiveness and prejudice, and, on the broad platform of tolerance for every sincere view, we consider with cold, passionless intellect the various thoughts that come, or are presented, concerning the relations between phenomena. Not all students of science have reached this point; many get into a groove which they wear so deep that they can see out in but one direction; they work to prove a theory rather than to make a better one; but the tendency is stronger in science than anywhere else toward breadth and tolerance. By those who know little of its controversies, science is accused of endeavoring to fasten her theories on mankind regardless of facts. These little suspect the joy that would fill a young scientist could he but assert, and plausibly maintain, some new hypothesis that would displace the old. This is the spring of life in science: the realization that all knowledge is relative, and that what we call truth is but the expression of views that at the time coordinate most phenomena. Next year, next day, may bring a new fact that will necessitate a new theory. This is no disgrace to science; it proves her to be alive and growing; it demonstrates her elasticity and perennial vitality. Let him who boasts of certainty and permanence beware lest he be found hugging a delusion born of prejudice and ignorance.

During the last half of the last century we heard much of the con-

flict between religion and science. There were those who maintained that no such conflict existed, and others who believed that there was war to the death. The present generation cannot appreciate the state of affairs that existed, so violent was the opposition to the then new teachings of science. To believe in the doctrine of evolution was to brand yourself as an infidel without further ceremony. To believe that the earth required more than the time represented by six of our ordinary days for its formation was scarcely less reprehensible. The doctrines of the conservation of energy and of mass were also dangerous, though perhaps less so because their tendencies were less apparent. I remember the horror which an old gentleman expressed for that uplifting and inspiring passage in one of Tyndall's brilliant lectures in which he traces nearly everything earthly to the sun. In his view, Tyndall left no place for God. For years Henry Ward Beecher was the only preacher of note that had the breadth and courage to avow his acceptance of the tendencies and teachings of evolution. There were doughty fighters on both sides. There were prejudice and intolerance on both sides. There was lack of sympathy with sincere convictions on both sides. I do not care to make quantitative comparisons at this time. As always, the younger generation is bearing the banner of progress, and in some form the views of science in respect to the age of the earth, the origin of species and the relations of matter and force are accepted with as little concern by this generation as the ideas of the rotundity of the earth and its diurnal revolution were accepted by the previous one. It is important to recognize, too, that, with this prevalence of the views of scientists, "pure religion, and undefiled" has suffered not the slightest loss. In fact, by the trend of events, the methods of science have been introduced into the study of religions, with the result that it has taken on new life, and there is every reason to believe that the future will show developments that will ultimately lead to the reunion of all who sympathize with all that tends to the moral elevation of mankind.

The nineteenth century will probably always rank as the century of science. Great as have been the material advantages resulting from the discoveries of that century, I believe that its greatest, its farthest-reaching triumph was the emancipation of the intellect. Science, by her unfaltering courage and superb accomplishment, has become the dominant power of society. The progress of scientific thought is but one phase of the general progress of liberty. The mission of science is but begun; her methods are being applied in all fields of mental activity, and progress in the study of economics, sociology, ethics and theology will be made by the application of the same principles that have advanced astronomy, physics, and chemistry, viz., an

unprejudiced mind, accurate observation, well-chosen experiment, and logical reasoning upon things as we find them, not as we imagine them or think they ought to be. When all approach these subjects in this way, we need have no fear concerning the effects of the progress. Thinkers of every type recognize that truth is a unit, of which each may dig out a bit, but none can have all, and that no fact can possibly be at variance with truth as a whole. Gerald Stanley Lee put volumes of sound theology in six words when he said "When a fact speaks, God speaks." The highest mission of science is so to amass facts, and to train minds by their study, that the so-called supernatural shall be brought within the realms of things known with the same degree of certainty that the things of chemistry and physics are known. Absolute knowledge beyond consciousness of our own existence and sensations we cannot attain. Speed the day when he who gathers truth from whatever field will be welcomed with his sheaves, no matter how unfamiliar the grain!